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BRIEF INTRODUCTION TO NONCONTACT TYPE LARGE-DIMENSION THREE-COORDINATE MEASUREMENT SYSTEM

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ABSTRACT

The paper presents a noncontact type large-dimension three-coordinate measurement system (LDMS) developed by the authors, thus realizing spatial three-coordinate measurements with ranges between several to tens of meters. The main indicators of measurements, such as precision and system function, have reached the advanced level of the same kind of system made abroad for extensive applications in aeronautics, aerospace, shipbuilding, power and architecture.

I. Principle of Measurement

The fundamental layout of the LDMS system includes two sets of model T2000S electronic transits, one set of IBM-PC microcomputer system, one set of data collecting device, as well as one set of measurement accessories. The principle of system measurement is shown in the only text figure.

When two sets of transits are simultaneously aimed at a spatial point P, if the central distance b of two transits is known, and based on the horizontal angles $_1$ and $_2$ as well as vertical angles $_1$ and $_2$ measured by transits T_1 and T_2, then we can derive the three-dimensional coordinates of spatial point P relative to the system coordinates.

Before operation of the system, it is required to use a datum rule of known length for calibration, thus determining the central distance b of the two transits, and establishing the system coordinates.

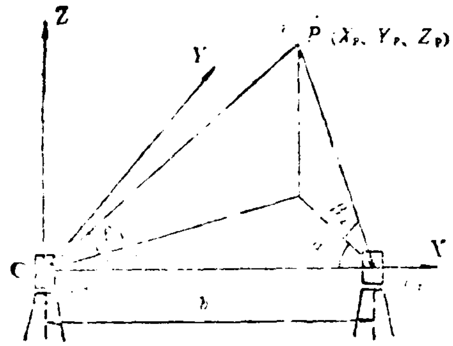
The measurement precision of the system is mainly determined by the angular measurement precision of the transit. On the model T2000S electronic transit adopted in the system, the angle measurement precision is 0.5" and its minimum resolving power is 0.1". Since the calculation of the coordinate value relies on angular measurement, the greater the distance from the target, the greater is the measurement indeterminacy. As shown by comparison with the experimental results, the length measurement indeterminacy of the system can be estimated from the following empirical formula:

$$U_{95} = K \times (0.01 + 10^{-2} \times L + 4 \times 10^{-3} \times D) \text{ mm}$$

In the equation, K is the coefficient related to factors of lighting and others; generally, the coefficient is 1 to 2. L is the measured length, and D is the average distance of connecting lines from the measured object to two transits. Both L and D have meter as unit.

II. Characteristics of Function

The measurement function of the system is comparable to the conventional three-coordinate measurement device, capable of directly measuring multiple geometric elements (such as point, line, plane, cylinder and sphere) as well as calculating inter-relationships, such as distance, included angle, intersection and projection. The system can conduct measurement and evaluation on multiple shapes and positions in addition to defining the supplementary elements. There are multiple supplementary functions, such as coordinate conversion, error treatment and conversion of system parameters.



As a large-dimension three-coordinate measurement system, LDMS has many characteristics. First, since the system uses a transit as its sensing device, the system can be used in making noncontact long-distance measurement. This feature allows it to be applied to cases such that the measured objects cannot be approached closely. Assembly and portability of the system are very convenient, since it is capable of being moving to various work sites and of being used in making rapid measurements. In addition, since the transit is an instrument ordinarily used in field operation, the LDMS has very high adaptability to working environments, capable of being used in the conventional production shop or outdoor working sites.

III. System Applications

Since the LDMS system has numerous features of measurement and calculation, as well as high adaptability, the system can be extensively applied to various fields of engineering measurement as follows: inspection and measurement of various models of frames and large structures in aeronautics and aerospace; measurements of random dimensions as well as errors of shapes and positions of large machinery parts and components in the heavy machinery manufacturing industry; measurements of shapes and planes of large antenna; deformation measurement of structures; as well as calibration of robot locus, among others. In the following, the presentation is based on two application examples of the system in engineering.

In August and September 1986, the LDMS system was employed in on-site measurements and tests at the Shanghai Aircraft Manufacturing Plant in its coproduction with the United States of MD082 large airliners during general assembly of fuselage model frames. There were the following items of measurement and testing: linearity and horizontal features of guide rail, gap between positioning holes of guide rail station position block and tool shaft, as well as installation positions of butt level plates in the front and in the rear of fuselage, among others. As shown by the measurement, the LDMS has features of simplicity, rapidity, precision, data display of inspection and measurements of multiple relations between geometric parameters and positions.

At the Xinglong Observation Station of the Beijing Astronomical Observatory, the Chinese Academy of Sciences, in October 1987, measurements were conducted with the LDMS system on a circular guide rail 21.6 meters in diameter in project 216 of the station. There were the following measurement items: surface horizontalness and horizontal features on guide rail, roundness and diameter (and other parameters) at the inner lateral surface of the guide rail. This measurement was conducted at an outdoor site atop a hill, thus indicating the very high adaptability to the working environment by the LDMS system.

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